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Research Report

THE TRANSMISSION OF TECHNOLOGY ACROSS NATIONAL BOUNDARIES

by

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The views and opinions expressed in this report are those of the author and are not necessarily endorsed by the Department of Industry, Trade and Commerce.

The Transmission of Technology Across National Boundaries

In the general debate on foreign ownership and Canadian sovereignty, the question of the transmission of technology has been largely overlooked. This is unfortunate because access to technology may have more to do with independence than has the fact of ownership. Canada's Churchill Falls power project - the largest single-site source of power in the western world - is an informative case in point. Five of the ten turbines and generators were supplied by Canadian General Electric - a majority foreign-owned subsidiary, while the other five were supplied by Marine Industries - a Montreal-based, "independent" Canadian firm. Marine Industries, a relative newcomer to the field of power generation, did not have sufficient in-house technology to handle the project, and had to secure it under license from a foreign supplier. Canadian General Electric on the other hand had developed a significant Canadian base of technology in the field and was able to proceed from its own resources with relatively little parent company assistance. The nature of the project required a good deal of technical discussion between the two firms, since all the turbines and generators had to be able to operate interdependently. The resulting technical discussions took place not so much between the two contracting firms, but between CGE's Canadian technicians and counterpart personnel from the foreign licensor.

The point to be made is that Canadian-owned firms, securing technology through license agreements, may be more constrained by and dependent on their licensors, than foreign subsidiaries are on their parents. The question has seemed worth researching in the light of the growing recognition that economic growth in the developed world is fueled largely by technological innovation, and that most multi-national firms are in the vanguard of technology.

This article then is about technology, or, more specifically, how some large divisionalized firms manage the transmission process across national boundaries, and how smaller domestic firms compete against them. It is the result of field interviews with three large divisionalized firms, Canadian General Electric, Westinghouse Canada and General Steel Wares. The former two are U.S.-owned subsidiaries while the latter is a Canadian-owned firm in competition with them. Some information was also obtained from other Canadian-owned firms in the industry. The term, transmission of technology merits closer definition. The focus of this paper is on how ideas originating in research centres are transferred to product divisions and how the divisions in turn influence the direction of research activity. Translating ideas into products, however, is not entirely a matter of scientific dialogue. It also involves quite pragmatic ingredients, such as product design, process design and the development of tooling, as well as the major uncertainties of market development. An attempt has been made to touch on all these considerations.

1. Technology in the Large Divisionalized Firm

Generalizing from a sample of three firms is necessarily hazardous, but perhaps not so much so when there is evidence that their problems may be representative of a large number of other firms. Of the top 500 U.S. industrial firms, for example, 430 operate with divisional, profit centred structures, while 70 are more specialized and centralized. The situation in Canada is not too dissimilar as the following information illustrates.

Features of 85 Large Canadian Firms

	Foreign-owned	Canadian-owned	Total
divisionalized	18	27	45
centralized	19 (9)	21 (12)	40 (21)
total	37	48	85

( ) = raw materials based firms

Divisionalization has been a popular, though not necessarily profitable, approach to growth. It has also provided a diversified base for research activity in many firms, of which GE and Westinghouse might be regarded as typical. These firms have developed enviable research competence and a high skill in managing the transmission process; so much so that the divisions and subsidiaries of these firms are part of a much more dynamic chain of technological communication than are their Canadian-owned competitors who secure their technology in the open market through arms length licensing agreements.

The heart of General Electric is at Schenectady. Westinghouse's counterpart research centre is in Pittsburgh. It is from these laboratories that the seeds of innovation are injected into the corporate system. General Electric's corporate research centre, for example, employs over 600 key scientists, and it is estimated that the annual cost per scientist including

support staff, workshop facilities for experimentation, and other overheads, ranges between $70,000 and $100,000. The head of corporate research reports directly to G.E.'s top executive body, enjoying the same status as the nine group vice-presidents each of whom supervises several product divisions. This structure enables a vitally necessary autonomy of action within the centre. It is counterbalanced by a unique budgeting system, however, which operates to tie the activities of the centre more closely to the needs of the product divisions.

The Westinghouse corporate structure differs, of course, but, there also, particular attention has been paid to linking the activities of the research centre to the needs of the product divisions. This is one vital lesson both firms have learned from their experience with central research laboratories: specific measures have to be taken to ensure a degree of direct relevance between the activities of the research centre and the commercial needs of the firm. Techniques for improving the accuracy, breadth and speed of information flows from the centre through the successive stages of product design and development, pilot production, market testing, product launch and feedback are also critical. Managing this complex two-way transmission process poses a challenge of major dimensions.

Effective communication of research findings requires a mutual scientific competence between both communicating parties. Partly for this reason, both GE and Westinghouse

have followed the approach of centralizing "basic" research at the corporate level and de-centralizing product development laboratories to the divisions. Centralized basic research capitalizes on the value of scarce ideas, while the decentralized laboratories provide the competence needed at divisional level to promote clearer communication.

A. budget and planning procedures

How can one avoid having the central lab expend its energy on matters that are trivial to the divisions? How can duplication at the divisional and central labs be prevented? How can the central lab develop a coordinated, long and short term research program if it has to respond always to the needs of the divisions? How can the flow of ever-scarce ideas be stimulated?

Many of these questions are answered through the budget and planning procedures at the central lab. The procedure at one firm was that the total research budget for any given year was fixed through discussion between the research director and the top executive group in the company. The top management then handed the product divisions a formula-based assessment for about half of the centre's requirements. Division managers had no say in the amount of this assessment. The research centre could count on it and could use it to finance programs that were undertaken at its own initiative.

The other half of the centre's budget came from contract funds, of which about half were derived from government agencies and half from the product divisions. Contract research could arise at the centre's initiative or at the initiative of the product division. In any event it must involve consensus as to content, purpose and cost. As a result, before

the contracting process got underway, the divisions needed to know what the centre planned to do with the assessed funds. And, of course, the centre attempted to accommodate, to a point, the interests of the divisions in the formulating of its preliminary plans. The point to be made, however, is that the research centre had the final say in how it would spend its assessed funds. What the divisions were unable to convince the centre to do, they had either to do themselves or pay for under specific contract with the centre. Product divisions seldom went outside the administrative unit of the firm to secure research help.

Although the budget and planning procedure of the other firm differed in its details, it also placed a portion of the budget under the control of the centre and a portion to be used on projects specified by the product divisions. This division of the budget reflected the recognition by both firms that the research centre had to preserve itself as an organism, and maintain its contact with the scientific community in order to serve the divisions effectively.

B. operating the centre

The research centre is one area where decentralization of responsibility is imperative. How does one maintain an atmosphere of scientific discipline on the one hand and individual initiative and responsibility on the other? How does one arrange for a reasonable career progression for research scientists?

How are scientists kept up to date in their fields of specialization? Should the centre be organized by discipline or by project - i.e. permanent or a transitory associations? Can a scientist carry his own brainchild through to the product stage?

These are elusive issues and no general rules can possibly capture all the nuances of the complex associations involved. Rigidity tends to be dysfunctional. Creative insights are rare; even amongst the trained they arise often in maverick personalities. It takes a perceptive administrator to detect brilliance and foster it across normal organizational channels. A number of useful practices were observed in Schenectady and Pittsburgh.

i. Highly selective hiring policies, involving recruitment of Ph.D's from the leading universities, maintained a high level of competence at the centre.

ii. A highly developed computer search program monitored abstracts from scientific journals using the key word principle. Scientists were kept informed of the writings and experiments of others within their areas of special interest, and were encouraged to publish themselves.

iii. Opportunities for advancement to managerial positions within the centre were necessarily limited. Some scientists by virtue of their disposition preferred in any event to stay "on the bench", but others opted to move into the product divisions after five to ten years at the centre.

a) Some scientists joined the centre with such a move already in mind, were assigned projects of special interest to the prospective division, and stayed less than three years.

b) Others chose to follow a particular piece of research that had captured their interest through to the product and market stage. This often involved, first, a move to the divisional lab, and second, a move into product management.

c) Yet others moved into product divisions either as a mode of research specialization or as a complete change of activity. Such moves were usually made before age 35-40, because otherwise one's value as a researcher began to outweigh one's potential value as a manager, and an equivalent salary move became more difficult.

iv. The organization of the centre tended to emphasize groupings by scientific discipline. However, this steady state posture was often interrupted by the need for interdisciplinary teams to work on projects initiated by product divisions. Individual scientists often had several projects going on simultaneously under the direction of different leaders, and faced difficult priority problems.

a) A researcher with a brainchild in its infancy had to convince others of its worth, but he had a choice of people to go at. He could try to

persuade his immediate supervisor to allocate some assessed funds to it: he could try, personally, to get it funded through the government or other philanthropic agency (the company could help him with contacts here): or he could try to sell it to a product division.

b) Projects sponsored from the centre may occasionally result in viable innovations that are outside the sphere of divisional operations (this happens less often, of course, with widely diversified firms). Some of these end up "on the shelf" or "for sale", but others may be exploited by the innovating scientists establishing an independent firm with the support and participation of the company.

C. Transmitting research results to the divisions

Effective scientific communication requires an absorptive competence at the receiving node. As a result there is a tendency for the centre to communicate, wherever possible, through the product division laboratories. Product division managers and their technical people are encouraged to visit the centre often and discuss the progress of projects they have initiated or which may be of interest to them. Reports are, in any event, sent out systematically by the centre, and scientists at the centre often use informal channels via "alumni" of the centre who have been transferred to the divisions. But all of this is not enough.

The development of new product concepts is one thing, but deciding in advance whether they will fill a market need at a given price is quite another. The divisions are profit centres. The performance of their managers is measured by return on invested capital. Managers do not stay in place very long (3-5 years). New products are often costly to perfect and introduce to the market. They tend to lose money in the early years. They hurt managerial performance. They are resisted.

Part of the reason for resistance is that research centres seldom do consumer research. The response channel from the market to the centre is often blocked. When the product under development is decidely new, this lack of market information tends to increase the risk at the product division level. Not so much so, however, with minor feature or design changes or with company versions of products which competitors already have on the market. However, product imitations and minor adaptations are often initiated by the divisions, and are, as a result easy to transmit. The receiver is more anxious than the transmitter.

But how does the centre get significant new product ideas into production if the division is reluctant? One way is to reduce the risk to the division by doing the product development, engineering and design at the centre and going into pilot production. A second step is to define the market for the product and to test it with the output of the pilot plant. These activities require at the centre skills which repose largely in the divisions. Necessity, however, breeds a degree

of imagination. One final move the centre can make is to urge central management to form a new division, or a new department within an existing division, to handle the new product.

In all these matters the tenor or climate of the organization, largely a function of prior decisions, is an important factor. Does central management tend to foster high risk research and an image of technological leadership? Are divisional managers penalized heavily for losses resulting from new product introductions or failures? Are divisional managers penalized for excess conservatism in resisting potentially valuable innovations? The conversion of science into marketable products is a high risk process fraught with the defensiveness of human insecurity. Effective management of the process is more important to the success of the firm, and more difficult to assure, then is the actual research itself. Those firms that do it well possess a competence rarely found in other institutions where research is done. Transmission across national boundaries, furthermore, introduces the complication of the competing needs of nation states.

2. Transmitting technology to foreign subsidiaries

The Canadian subsidiaries of GE and Westinghouse are organized on a horizontal basis. They represent independent, autonomous profit centres. They are not integrated into the affairs of their parent companies as are the vertically structured auto subsidiaries. The parent research centres are wide open to the Canadian subsidiaries at relatively little cost. But, the availability of the centres is not the critical issue; it is managing the transmission process that counts, and this seems to depend a good deal on the initiative of the subsidiaries.

A. The general rule

In practice, the subsidiaries obtain their technology largely from their product division counterparts in the United States, and seldom from the research centres. Furthermore, royalties paid by the subsidiaries are credited to the product divisions to encourage a cooperative working relationship. It was, in fact, often repeated, at both sides of the border, that very strong personal friendships had developed between Canadian engineers and their American counterparts in the product divisions which made the transfer of product technology virtually problem free.

Why do the subsidiaries not develop their own independent channels to the research centres? Why do they deal almost exclusively with the product divisions? A variety of explanations was offered.

i. In most areas the subsidiary does not have the in-house skills to absorb from and contribute to the work of the centre. The subsidiary does receive detailed technical reports on projects underway at the centre, but this is a one-way process. It does not result in innovation by the subsidiary.

ii. The subsidiary as a profit centre is seldom as profitable as U.S. based product divisions, and it pays little or nothing towards the costs of the research centre. The result is that the U.S. divisions are expected to carry the entire cost of research, since:

a) they have the profits to commit to it.

b) they have a much larger market potential for new products flowing from research.

c) they work with established two-way liason between themselves and the centre. They are experienced managers of innovation.

iii. The parent transfers other skills than product technology to the subsidiary. These include process technology, market research results, related advertizing programs, cost and quality control systems and management training.

These skills are transmitted by the U.S. product divisions, with the result that a broad, well-oiled transmission process has emerged which it has seemed natural to use for product technology as well.

B. Exceptions to the rule

Reality invariably defies generalizations. The parent-subsidiary relationship is complex; exceptions to the general rule are commonplace and at least as interesting as the rule itself. What, for example, happens when the parent drops a particular product line and the subsidiary decides to stay in? Who does research and development on uniquely Canadian problems? Does the subsidiary ever innovate? If so, can the subsidiary export its new product through the U.S. product division's marketing system?

1. The subsidiary alone

Westinghouse recently stopped producing colour television sets and withdrew from the small appliance market. In both cases the company's central problem was inadequate market share - failure to achieve the critical mass required to sustain reasonable unit costs of production, marketing and research. In the case of small appliances, however, it was also felt that the level of technology was too low resulting in short lead-times for new products. A research intensive corporate structure has trouble surviving in areas where the rewards to innovation are shortlived.

Westinghouse Canada decided to go it alone in small appliances. The Westinghouse market share in Canada was greater than in the U.S. and the Canadian subsidiary was not so research intensive. With the technology pipeline to the U.S. closed, the subsidiary was forced to seek licenses from other established producers. These outside licenses, however, were regarded as an interim step toward the development of in-house technology, and the subsidiary had already selected specific products for which it intended to have in-house skills.

Westinghouse Canada also tried to go it alone in colour television where the required level of technology was considerably higher, and again they faced the difficult task of building in-house skills. The parent company gave all the assistance it could including the transfer of certain equipment, some institutional markets in the U.S., and a whole series of license agreements where the parent had been licensor. Over a period of a year, the subsidiary was in fact successful in developing a team of technologists capable of servicing the license agreements and developing the state of the art in the future. However, the process was not easy. Experienced Canadians were hard to find and key American technologists were expensive (25-30% above their U.S. salaries, in part because of higher personal tax rates in Canada). Furthermore, the attempt was terminated, at a considerable loss, before the new team could really prove itself. The viability of the whole project was very dependent on exports, and the union attempted to exploit this vulnerability by high wage demands. A prolonged strike resulted causing substantial

loss of overseas customers. In addition, the Canadian exchange rate increase made it increasingly difficult to compete in world markets. The project was abandoned in 1972.

2. Problems unique to Canada

In the field of heavy industrial goods, the market in Canada was on occasion different from the U.S. market. Some differences were so substantial that it was necessary for some pioneering research to be done in Canada. CGE, in fact, had two small laboratories functioning in Canada; one in Montreal and one in Peterborough. They were intimately associated with corresponding product division laboratories in the U.S. and also maintained liason with the research centre. The company had in fact recently purchased a plane to facilitate daily travel to and from Schenectady.

CGE's heavy apparatus group at Peterborough contained five product departments which together had the product scope of 30 U.S. product departments. "The only way we can sustain such a wide product scope in Canada", said one Peterborough manager, "is to secure the related technology from the U.S. at low cost. If we had to develop this span of technology in-house on our sales volume, we'd go broke in the process".

"There are some advantages on the other hand from being less specialized than the States. Sometimes industrial systems are put together from products made in entirely different divisions down there, whereas we may make all the components in Peterborough. We've often been able to streamline and simplify their systems designs as a result. What's more they've even helped us do it. They've sent down customer industry experts

to help us understand more precisely what a given system has to achieve..."

3. Innovation in Canada

Some technology intensive innovations do occur in the subsidiaries in the manner just described, and the subsidiaries are sometimes found in competition with their parents for overseas contracts. Such competitive activity, however, requires some unique development effort on the Canadian side - something to differentiate the Canadian product from its parents' line. This in turn requires a measure of in-house technological skill in the subsidiary.

When a product has a high technological content (i.e. imitation is difficult) the subsidiary is usually dependent on the parent for pioneering work. "We let the richer U.S. divisions pay the research costs. Then we get involved at the product development stage, often by sending one of our men to work on the development team." Subsidiary involvement in the development process has often led to creative adaptations somewhat akin to innovation, and possible only because of close liason between subsidiary and parent.

When the technology content of the product is low, the in-house skills of the subsidiary may be sufficient to develop it without parent company help. The impetus to do so often comes from competitive activity in the market place. CGE, for example, recently introduced a lawn trimmer in Canada in response to a competitor's innovation. The parent company did not make a similar move, and CGE was able to secure access to the U.S. market through GE's extensive distribution system.

It might be argued that, if subsidiaries could obtain some outside technology to supplement what is available to them through their parent affiliation, they would stand a better chance of developing significant product innovations in relation to the enterprise as a whole. This raises the question of whether Canadian subsidiaries are allowed to secure technology from sources other than their parents or whether they are "restricted" to the family fold. Answers varied widely from person to person: "The Canadian division can go wherever it wants for technology"..."The parent expects us to go their first, but that's the kind of restriction nobody minds"... "Where else is there to go?"..."The initiative doesn't come from us; it comes from the Canadians. It's up to them." The interesting thing about these diverse reactions was that the question was not viewed as a matter of power (authority) within the corporate system, but as a matter of attraction (competence). It's rather like being required to have lunch in Paris instead of New York.

The reason for this, however, lies not just in the competence of the parents' research centres, but also, and perhaps mainly, in the way the transmission process is managed. The technology elsewhere would have to be substantially more advanced or substantially cheaper. But this does happen on occasion. In consumer electronics, the Japanese did move well ahead of the U.S. giants, and Canadian subsidiaries were either slow to recognize this or loathe to act on it.

3. Technology and the Canadian-owned Firm

Securing technology in a dynamic setting has been shown to involve three distinct processes:

a) ease of search for relevant knowledge (which divisionalized multi-national firms seem to handle very efficiently);

b) development of enduring relationships through which information can flow quickly with minimum distortion; and

c) adaptive strength at the receiving point

Do Canadian-owned firms fare better than foreign subsidiaries in managing these processes? The answer for many is, regrettably, no! Foreign ownership in high technology industries in Canada is high. Subsidiaries with access to parent technology make very tough competitors. One Canadian executive who had managed in both kinds of firms made the observation that: "In the Canadian-owned firm we know what we want to do but don't know how to do it; whereas in the subsidiary we knew how to do it but had difficulty deciding what to do." The difference is access to detailed technology.

Canadian-owned firms, in the absence of foreign ownership ties, tended a) to seek technology under license - usually from foreign licensors; b) to operate through the distortion of transitory and often arms-length relationships, and c) to overlook the development of in-house adaptive skills.

Licenses seemed to fall into three general types:

1. All technology currently developed or to be developed by the licensor (sometimes including his brand name).

2. All technology now in place by the licensor (the licensee must have in-house skills to develop future changes himself).

3. License for a specific patented product, component or process (in widespread use by most major firms).

The first type often contained restrictive clauses for the defense of the licensor, in regard to such things as market limits and product adaptations. The tendency for Canadian-owned firms was to opt for this type of license, and to license as many products as possible from the same source in order to minimize problems of transmission. In the words of one Canadian executive: "Licensing is like marriage. You may hold a license but that doesn't solve all the problems that arise. You have to work at it." Presumably, bigamy is that much less managable.

What was more discouraging was that many Canadian firms had not developed in-house absorption skills, and remained dependent on the licensor for even minor changes in technology. Often the licensor would send skilled technicians into the Canadian firms to iron out problems during the start up of a new product or the introduction of some new feature. Canadian firms receiving this help developed what one executive described as a "foreman mentality in management". Operations tended to be run on a day-to-day basis. Managers had

so little control over the speed and direction of the licensor's research, that they were generally unable to formulate integrated long-range plans.

Furthermore, the cost of technology to these firms on the open market was probably higher than the cost through a single administrative unit, such as a multi-national enterprise; the speed of transmission was probably a good deal slower; and the range narrower. As a result the Canadian licensee was usually forced to operate with thin management in order to match costs with the foreign subsidiaries. Exports were minimal in these conditions since the Canadian licensee had neither a cost advantage nor a product advantage in international terms. In addition, a major risk accrued to such licensees (i.e. those operating without in-house technology): the failure of the licensor to keep up with competitive technology could leave them powerless to adapt to changes in the market.

A. Why don't Canadian firms build in-house technology?

If it is costly and risky to operate a business without in-house technology, why do many Canadian-owned firms insist on doing it? The answer seems to be that good product or process technology is difficult to acquire in the open market and there is hence a real fear of severing the cord. To change from a licensee policy to a policy of building in-house technology also requires a sizeable commitment of funds that the former policy seldom generates. Under present patent and anti-trust laws, there are two transitional approaches open to Canadian-owned firms.

1. Undertake specific, product-related, research projects, or
2. Make a permanent investment in research and product development personnel.

The first approach is the one most encouraged by the piecemeal research incentives offered on a project basis by the Canadian government. But it is a piecemeal approach, and consequently suffers from a number of deficiencies:

a. the marginal cost of the project to the firm will be higher than it would be if in-house skills were in place first.

b. the probability of success may be lower than it would be in a subsidiary. Lack of prior experience, haste, and the uncertainty induced by transitoriness will all contribute. The subsidiary, on the other hand, is likely to have had some prior experience and to have recourse to the parent in the event of unforeseen difficulties.

c. if the research involved a significant new product, the Canadian-owned firm, due to its history of followership, may face consumer reluctance when it tries to play the catalytic role in the diffusion process. The firm would likely predict lower potential incremental sales than would a subsidiary.

For all these reasons, new product development projects have seldom withstood the rigours of cost-benefit analysis by Canadian-owned firms. It is the subsidiaries, in all likelihood, that have applied most frequently under the Canadian government's research incentive legislation.

The second approach implies a major corporate commitment not just to the notion of ongoing research but to an integrated strategy of competition by innovation. In order to achieve the research competence for such a strategy, Canadian-owned firms would have to build two structures:

1. Controlled access to centres of research, and
2. In-house absorption capacity

The task of setting them in place, however, is both difficult to do, and difficult to justify by normal cost-benefit analysis. What it seems to require is not merely executive recognition, but a sense of conversion - a sense of mission, and a viable scale of operations. These requirements constitute a formidable and costly barrier. But it is a barrier which must be crossed if Canadian-owned firms are ever to develop significant product differentiation. Those that achieve it will be in an excellent position to penetrate export markets (a further capital barrier) and thus reinforce the payoff to research.

B. Is lack of capital the main problem to Canadian-owned firms?

Some Canadian executives have come face-to-face with the problem and have recognized that securing controlled access to technology is a matter of central strategic importance. Recognition of this fact did not come easy; it required a reversal of the conditioning generated by decades of followership.

One executive who tried to do something about it found that capital shortage was not the only difficulty to

over-come. Finding a Canadian manager for a research centre, for example, proved a major obstacle. Developing in-house absorption skills was equally difficult; production engineers experienced in adapting new designs were hard to find in Canada. Creative industrial designers? Not quite as difficult but still a problem.

"We were trying to do something so unusual, so uncharacteristic of Canadian industry, that the resources we needed were simply not available in the country."

The result is that the Canadian-owned firm that attempts to move into the vanguard of technology in competition with subsidiaries of multi-national corporations, faces a formidable array of problems. That some firms are attempting it is creditable indeed, and worthy of government support.

4. Implications and conclusions

A. On the basis of this preliminary investigation, it appears that the transmission of technology within an administrative unit is more efficient - in terms of speed, cost and scope - than transmission across the open market. This introduces a systematic bias to the economists' established assumption of "perfect knowledge". Knowledge may be freely available, but the selective transmission of it is not. The bias favours the large firm, and has doubtless contributed to its growth and divisionalization.

B. Managing the transmission process is an extraordinarily complex and sensitive affair. Insecurity, risk and rapid change abound, and demand an adaptive system with the

major constraints aimed at controlling relevance. It is competence with this difficult process that prevents the large firm from going the way of the dinosaur.

C. Ownership can be changed at the stroke of a pen, but the technology transmission process is not easily replicated. Divisionalized, multi-national firms allow extensive autonomy to their divisions - domestic and foreign - and expect most initiative in communication to originate there. Their strength rests less in the power of ownership than in the attraction of competence.

D. Canadian-owned firms attempting to compete with divisionalized subsidiaries have to cope with inefficient channels to outside technology, and high capital barriers to the development of in-house technology. Government help along one or the other of these dimensions would accelerate the independence of the Canadian-owned firm. The absence of innovation in Canada is so extensive and of such long duration that experienced research technicians, production engineers and industrial designers are hard to find. Forms of subsidized training seem to be called for.

E. Piecemeal, project-oriented research grants seem less likely to lead to product innovation than does ongoing support of "permanent" research centres. Government funding should reflect the importance of enduring relationships in easing the transmission process over time.

F. Getting relevant information through the various stages from research centre to product ideation and development, pilot production, market testing, launch and feedback is complex enough without placing the stages under different administrative units. Industrial research activity belongs in firms, not in governments and universities, and Canada is seriously out-of-step in this regard with the rest of the developed world. This is not intended to imply that there cannot be a helping relationship in research between governments, universities and firms. But the administrative control of industrial research should be in the hands of firms.

G. The opportunity and climate seem right to encourage more Canadian-based research activity by subsidiaries. Canadian subsidiaries already have unique access to parent research centres and could well expand their role, given the right incentives, to secure some outside technology on occasion and to become centres of technology for the entire administrative unit in certain selected product areas. Such centres would provide high quality employment to Canadians, an opportunity for innovative skills, and a good base for exports. Surely these have more to do with national sovereignty and independence than does the fact of ownership.

TECHNOLOGICAL INNOVATION STUDIES PROGRAM

PROGRAMME DES ETUDES SUR LES INNOVATIONS TECHNIQUES

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